Response to Comments: Proposed Measures to Reduce Refrigerant Leaks from Commercial Refrigeration Systems

(As presented at the stakeholder meeting on December 16, 2010)

Measure #1: *Piping runs using threaded pipe must not be used for refrigeration lines (e.g., if steel piping is used, it must be welded*). *This does not include the control connections at the compressor.*

Comment: Care will be required so that unintended items are not included in the field piping proposal; an example might be a threaded fitting on an oil separator clean out port. (Buzz Schaeffer, Hussmann)

> **Response:** We are only concerned with the refrigeration lines piped throughout the store and not ones at the compressor rack. We will revise the language of the measure to clarify this.

Revised Measure #1: *Piping runs using threaded pipe must not be used for refrigeration lines (e.g., if steel piping is used, it must be welded*). *This does not include threaded connections at the compressor rack.*

Measure #2: *The use of copper tubing with an outside diameter (OD) smaller than ¼" is prohibited in all but systems with a refrigerant charge of 5 lbs or less. When using ¼" tubing, it must be clamped to a rigid base every 2 feet.*

Comment: There is slight concern over the requirement of "every two feet". The proper distance for clamping is dependent upon the frequency the tubing is exposed to as well as the design and material of the tubing. Mandating a set distance could transfer stresses to other components such as fittings or connections leading to premature failure. (Buzz Schaeffer, Hussmann)

> **Response:** The goal of the measure is to ensure the tubing is clamped to minimize harmonics in the tubing. Rather than requiring a set distance, the maximum vibration level will be

Revised Measure #2: *The use of copper tubing with an outside diameter (OD) smaller than ¼" is prohibited in all but systems with a refrigerant charge of 5 lbs or less. When using ¼" tubing, it must be securely clamped to a rigid base so that the vibration level is below 8 mils.*

Measure #3: *Flare fittings are prohibited from use on all refrigerant applications with the exception of pressure controls, valve pilot lines, and oil lines. In these exception cases, pressure controls and valve pilot lines must use double-flare connections.*

Comment: This measure is redundant of the recommendation in the new ASHRAE Standard 147. (Sam Cantrell, Raley's)

> **Response:** ASHRAE Standards are not required under California's law.

Comment: The head of procurement engineering at Hill-Phoenix refrigeration manufacturing in Conyers, GA (Philip Stephenson) developed a case study a few years ago on flare fittings; leak rates at flare fittings detected within the factory-controlled environment grossly exceeded all other leaks on the rack systems. A flare feral was identified with multiple ridges that, when properly installed, offers 5-6 compression points versus the standard one compression point. (Robert Edison, Aztec-Energy)

Response: No response necessary.

Comment: It is true that flare fittings, which are typically used in instrumentation, pilot, and control lines, have proven to be a troublesome connection in most refrigeration systems. However, requiring flare connections to be double-flare will increase the risk of leaks at these fittings. Double-flares are difficult to produce correctly. The excessive flaring and bending of the tubing can easily lead to hidden stress fractures which will manifest themselves only after their installation and hours of operation. Damaged double flares are not repairable and require replacement of the entire tubing. We have developed a technology to solve the leakage issue in flare fittings—a multi-ring ("Flaretite Seal") seal with a special (Loctite™) coating. The multi-ring seal can snap onto any standard flare fitting and, when properly installed, guarantees the fitting to be leak free. The seal adds a second layer of conforming copper material to the flared area of the fitting (similar to the double-flare), while the coating (which is dry to the touch) fills small voids and prevents intermittent leaks that are difficult to find and repair. The multiple sealing rings on the seal compensate for variations in fitting and valve manufacturing and allows for leak-free installation of tubing with minor misalignments (a common problem). The technology has been proven in thousands of applications around the world, including military and commercial aviation, industrial hydraulic and pneumatic equipment, and commercial refrigeration applications. I have attached our recent article of leak prevention with a major manufacturer of commercial refrigeration equipment, which you should find helpful.[1] I have also attached a test report from Eaton Corporation, Eden Prairie, MN where our seals were tested to the most stringent requirements in the fitting industry, and we excelled. Accordingly, I propose that you amend "Measure #3" to include single flares fitted with Flaretite seals, since the use of such seals would significantly decrease the costs of refrigeration system manufacturing and installation while offering a superior, leak-free connection. Specifically, we suggest revising the measure to read: "Flare fittings without an additional multi-ring seal are prohibited from use on all refrigerant applications without exception. Flare fittings used in supply and return lines, pressure controls, valve pilot lines, oil lines, etc. are to be fitted with an additional multi-ring seal coated with an industrial sealant suitable for use with refrigerants. All flare fittings are to be properly tightened to the manufacturer's recommended torque setting with a certified torque wrench." (Vito Accetta, Flaretite)

Response: Although Flaretite assures that their technology is proven to prevent leaks, the technology is not believed to be widely used in supermarket refrigeration applications in the United States. A primary proponent and user of this technology is equipment manufacturer, Hill Phoenix, whose representatives have confirmed that the use of multi-ring, pre-coated copper gaskets has solved their problems associated with leaking flare connections. However, according to one representative of a major refrigeration component manufacturer, Mueller Industries, neither double-flares nor single-flares with coated multi-ring flare seals are noticeably better than a standard single-flare connection. According to this source, a simple single-flare connection is as good as any other flare connection, and there is little field experience with multi-ring seals to prove otherwise. One other industry representative (from

[1] http://www.achrnews.com/Articles/Feature_Article/BNP_GUID_9-5-2006_A_10000000000000710516

Hussmann) also recommended additional field research and testing be conducted before such seals are broadly mandated on flare fittings for all refrigerant applications. Since flare fittings are known to contribute substantially to refrigerant leaks in certain applications,[2] yet there is not consensus on how to best minimize leaks in cases where flare fittings must be used (i.e., on pressure controls, valve pilot lines, and oil lines), single-flare connections with multi-ring seals coated with an industrial sealant will also be allowed in those exception cases.

Comment: Suggest that wording be included to cover pre-manufactured flare "machined fittings" which are even better than double flared connections. (Buzz Schaeffer, Hussmann)

Response: Only flared tubing connections are covered by this measure; therefore, it is implied that machined fittings may still be used. The language of the measure will be revised slightly to clarify which fittings are subject to regulation under this measure.

Revised Measure #3: *Flared tubing connections are prohibited from use on all refrigerant applications with the exception of pressure controls, valve pilot lines, and oil lines. In these exception cases, the tubing on a flare connection must be either (1) double-flared or (2) single-flared with a multi-ring seal coated with an industrial sealant suitable for use with refrigerants. All flared tubing connections with a multi-ring seal must be properly tightened to the manufacturer's recommendations.*

Measure #4: *Pressure relief valves must be equipped with a device to indicate a release of refrigerant such as a manufacturer-installed diaphragm with a visual indicator.*

Comment: Rupture discs should not be used because they will cause a complete system loss of refrigerant. Use pressure relief valves instead. (Sam Cantrell, Raley's)

Response: The use of rupture discs are important for indicating that a refrigerant leakage event occurred. The discs (or some other indication mechanism) should be used in combination with a pressure relief valve, not in place of one.

Comment: This requirement may be incompatible with the designs of new technology such as CO_2 refrigeration systems. (Buzz Schaeffer, Hussmann)

Response: This measure is aimed at systems that use high-GWP refrigerants. It is also not applicable to refrigeration systems that do not have pressure relief valves. Language will be added to the measure to clarify that only systems with high-GWP refrigerants are applicable.

Revised Measure #4: *Pressure relief valves installed on a refrigerant vessel containing a high-GWP refrigerant shall have a rupture disc installed between the outlet of the vessel and the inlet of the pressure relief valve. The space between the pressure relief valve inlet and rupture disc shall have a pressure gauge, pressure transducer, or other device to indicate a disc rupture and discharge of the relief valve.*

[2] According to IOR (2010), refrigerant loss data indicate that leaks from flared joints account for approximately 50% of all refrigerant losses in a typical supermarket. The paper is available online at: http://www.realzero.org.uk/web_images/papers/April%20paper%20laid%20out.pdf

Measure #5: *Only Schrader access valves with a brass body are permitted for use. For systems with a refrigerant charge of 5 lbs or more, valve caps shall be brass (not plastic); a neoprene O-ring seal must be in place, if designed for it.*

Comment: I wish there was a way to keep the seals intact - many times they fall out when you take the caps off and are never re-installed, thereby eliminating the leak reducing capabilities of the cap. I don't see this as often on Schrader caps but more on packed angle valve caps. (Robert Edison, Aztec-Energy)

> **Response:** It is recognized that seals and O-rings do fall out and are not always replaced; however, specific maintenance practices (e.g., re-installing lost caps) are out of the scope of these proposed leak reduction measures, which apply only to system design and installation. The intent of this measure is only to ensure seals are intact during installation.

Comment: Many manufacturers offer steel valves making use of steel Schrader access ports. Are these valves included, or does this refer to a stand-alone Schrader valve that would be installed at the OEM or end-user level? (Mueller Refrigeration)

> **Response:** Steel would also be an acceptable material to use for Schrader valves and caps. Plastics caps are the primary concern, as they aren't as durable as metal.

Comment: "Schrader access valve" is understood to mean an access fitting with valve core installed. Are access fittings without valve cores or access fittings without the capability to use valve cores also being considered? (Mueller Refrigeration)

Comment: Many manufacturers use a neoprene seal, though not technically an O-ring seal. We interpret this as being acceptable since the cap is designed for this style of sealing. Access ports that do not contain the valve core typically have caps that require the use of a wrench for sealing. These caps typically use copper gasket seals and we understand this to be acceptable since they are not Schrader valves (no valve core). (Mueller Refrigeration)

> **Response:** Yes, a neoprene seal that is not technically an O-ring seal would be acceptable if that is what the cap is designed for. Access fittings without valve cores or without the capability to use valve cores are not impacted by this measure.

Revised Measure #5: *Only Schrader access valves (i.e., access fittings with a valve core installed) with a brass or steel body are permitted for use. For systems with a refrigerant charge of 5 lbs or more, valve caps shall be brass or steel (not plastic); a neoprene O-ring seal must be in place, if the cap is designed for it.*

Measure #6: *Valves not having an internal stem diaphragm must have seal caps with chain tethers to fit over the stem.*

Comment: I agree 110%. In some stores I visit, I find hundreds of caps missing and usually laying near where they were removed. A chain or other device that permanently attaches all caps to their valves so technicians are more likely to re-install them following maintenance/repair work will be beneficial. (Robert Edison, Aztec-Energy)

Response: No response necessary.

Comment: This statement is interpreted as applying to diaphragm valves, since they do not have traditional stems or seal caps. If this references valve types other than standard diaphragm valves, using O-rings or packing as sealing methods, we would like a more detailed definition. (Mueller Refrigeration)

Comment: The brass caps on Schrader valves should not cause undue burden on OEM's. However, when taking Measure # 6 into account / definition it would seem that all of these brass caps will now also require a "chain tether". Also, if ones goes by the strict definition of an internal diaphragm valve seal almost every valve utilized in supermarket will require a "chain tether". We might suggest that this definition be reviewed to capture the intended components. Also, depending upon the strategy implemented by the valve /component manufacturers, this 'chain tether" requirement may lead to special inventory and engineering requirements and other internal processes for just the CA market, which would drive up costs to the OEMs. (Buzz Schaeffer, Hussmann)

Response: This measure is only applicable to standard diaphragm valves that are specifically designed for seal caps. For these valves, the seal cap must be in place and the valve must be fitted with a chain tether as a way to ensure the cap does not get lost during operation. Caps that are not physically removed from the valve during operation will be exempt from this measure.

Comment: Several manufacturers provide 2-piece seal caps that are not physically removed from the valve during stem operation. A tether does not provide any benefit in this scenario. The tether only keeps the cap with the valve; it does not ensure that the caps are installed with the proper cap seal in place. We would like to see caps that do not require removal exempted from this requirement. (Mueller Refrigeration)

Response: It is reasonable to exempt from this measure caps that are not physically removed from the valve during operation.

Revised Measure #6: *Valves that are designed to have seal caps must be in place with chain tethers to fit over the stem. Valves with seal caps that are not removed from the valve during stem operation are exempted from using chain tethers.*

Measure #7: *Evaporator coils in deli cases must be coated to prevent corrosion from vinegar and salt solutions in the displayed product.*

Comment: The term deli case is overly broad and may include cases that do not contain corrosive contents. (Unidentified meeting participant)

Comment: I believe you should describe these cases as "service type" deli cases, those are the cases that seem to be prone to leaks. We have lots of "self service" type deli cases that have packaged meats and cheeses that have no problems with leaks. (Rob Uhl, Safeway)

> **Response:** The measure is in reference to only service deli cases; we will better define "deli cases" to clarify that these are cases holding food products containing vinegar and salt.

Comment: If an OEM chooses to utilize a stainless steel coil you would not want to add the extra costs of coating the coil. (Buzz Schaeffer, Hussmann)

Comment: The prescriptive measure of coating needs to be dropped. Alternate materials are continuously being evaluated which may not require a coating. We suggest that this measure be revised such that the coils be designed to resist corrosion per some established specification. Ref: ASTM specifications. (Buzz Schaeffer, Hussmann)

> **Response:** We will clarify that such cases should have coated evaporator coils or be made of a corrosion-resistant material, such as stainless steel, to prevent corrosion.

Comment: Please keep in mind a coated coil will have a lower heat transfer capability and, hence, higher energy usage at the compressor. (Massoud Neshan)

> **Response:** While it is true that coil coatings may reduce the heat transfer efficiency of the coils, generally, this heat transfer reduction is minimal and may be offset by the coil manufacturer through design modifications (since different coatings have different energy efficiency ratings). Specific requirements regarding the specific coating to use are not provided in the measure as not to stifle future innovation; however, language will be added to recommend that coil coating efficiency be considered to ensure maximum efficiency.

Revised Measure #7: *Refrigerated service cases holding food products containing vinegar and salt shall have evaporator coils coated to prevent corrosion from these substances or be made of a corrosion-resistant material, such as stainless steel. The heat transfer efficiency of the coil coating should be considered when selecting the coating to ensure maximum energy efficiency.*

Measure #8: *Piping and components, such as liquid level indicators, shall be installed in such a manner as to protect the piping and components from physical damage.*

Comment: This is a very vague statement and I am not sure it will be easy to enforce. For example, my idea of how you would install piping and components in order to protect them from physical damage may be greatly different than yours. (Rob Uhl, Safeway)

Comment: Measure #8 is subjective; and would be hard to define and enforce. (Buzz Schaeffer, Hussmann)

> **Response:** It is true that this measure is not enforceable as it is currently phrased. Without more specific guidelines and an established system for verification, we will delete this measure from the proposed listing.

Revised Measure #8: Measure deleted

Measure #9: *Refrigerant piping shall be installed in such a way so that it is accessible for leak detection and repairs.*

Comment: Eliminate underground pipe runs. (Robert Edison, Aztec-Energy)

> **Response:** Underground pipe runs are permitted as long as the piping is accessible (e.g., via removable tiles, tunnels, etc.) for leak inspection and other maintenance.

Comment: Measure #9 is subjective; and would be hard to define and enforce. (Buzz Schaeffer, Hussmann)

> **Response:** The accessibility of piping is somewhat subjective but can reasonably be enforced.

Revised Measure #9: No changes necessary

Measure #10: *Install receiver level sensors on receivers with 200 pounds or more of refrigerant.*

Comment: The type of sensor will depend on if it is a horizontal or vertical receiver. The sensor could also be electronic. (Unidentified meeting participant)

Comment: When you look at liquid level sensors, should it be a gauge [dial indicator] or a more sophisticated sensor? Need to specify a minimum requirement. Sensors fail and need to be replaced. You need to have a way to replace the sensors. (Unidentified meeting participant)

> **Response:** A variety of devises can be used to measure the receiver level, with certain types of sensors being most appropriate for specific types of receivers. We do not wish to limit the types of devices for use at this time; any receiver level sensor may be used, regardless of its sophistication. While sensors may fail during operation, replacing sensors is out of the scope of these leak reduction measures, which only cover system design and installation.

Comment: This measure is a concern. We have used receiver liquid level indicators for over 10 years. The indicators have not been very reliable for leak detection. The problem has not been due to any fault of the device. The receiver levels are constantly in flux in many of the systems at our sites, making that method of leak detection difficult. Minimum refrigerant charge procedures, some HFC refrigerants, and aggressive energy reduction measures all tend to play havoc on receiver levels. It takes quite a bit of data collection and control work to be able to use the level indicators with some confidence. More emphasis is now placed on upgrading our leak detection system with upgraded sensors in more locations. (Lance Durr, Stater Bros Market)

> **Response:** While it is recognized that the receiver level is not the perfect indicator for identifying refrigerant leaks, there is still value in monitoring the maximum and minimum receiver levels over time to detect significant changes in refrigerant. This measure is believed to be complementary to ARB's refrigerant management program requirements.

Comment: It would be great if there was an EMS system out there that could sample the receiver level, base line to rack load, and then send alarm when the percentages do not match at the same time of day intervals (indicating less refrigerant in the receiver and, therefore, a leak in the system). (Robert Edison, Aztec-Energy)

> **Response:** It is possible that this technology exists but an algorithm would need to be written to accomplish this.

Revised Measure #10: *Refrigerant receivers with capacities greater than 200 lbs. shall be fitted with a device that indicates the level of refrigerant in the receiver.*

Measure #11: *Pressure test system during installation prior to evacuation & charging: (1) Charge the system with regulated dry nitrogen and the appropriate tracer gas to bring system pressure up to 300 psig minimum; and (2) after the system has been checked for leaks and all leaks have been repaired and retested, the system must stand, unaltered, for 24 hours with no more than a +/- 1 pound pressure change from 300 psig, using the same gauge.*

Comment (in response to #11 and #12): This would be great if passed - currently store marketing wants cases swapped and up and running in 8-10 hours which gives contractors barely enough time to set and pipe cases. (Robert Edison, Aztec-Energy)

> **Response:** No response necessary.

Comment (in response to #11 and #12): Industry standards for valve external leak rates, which impact both the pressure and evacuation testing, are typically <0.1 oz/year. Since leaks are cumulative and system volumes vary, do baseline numbers exist that support this is an acceptable rate? (Mueller Refrigeration)

> **Response:** These rates were developed, assessed, and adopted by EPA's GreenChill Advanced Refrigeration Partnership; GreenChill members, as well as other supermarket owners, have successfully achieved these rates. In this way, they have been validated by industry and are deemed reasonable.

Revised Measure #11: No changes necessary

Measure #12: *Evacuate system following pressure testing & prior to charging: (1) Pull a system vacuum down to at least 1000 microns (+/- 50 microns) and hold for 30 minutes; (2) Pull a second vacuum to a minimum of 500 microns and hold for 30 minutes; and (3) Pull a third vacuum to a minimum of 300 microns and hold for 24 hours with a maximum drift of 100 microns over the 24-hour period.*

See comments under measure #11.

Revised Measure #12: No changes necessary

General Comments

Comment: I would like to see the elimination of 90-degree short radius elbows on liquid lines or high pressure piping; often we get hydraulic effects from higher pressure systems which can and often do break through these short radius elbows. I recommend using Sweeping elbows or a Tygon bender. (Robert Edison, Aztec-Energy)

> **Response:** It is agreed that short radius elbows are more susceptible to stress on refrigeration lines (especially where there is thermal expansion and vibration) than long radius elbows; therefore, a measure will be added to address this. However, there are instances where long radius elbows cannot be used due to the confines of the space; in these instances, short radius elbows will be acceptable for use. Sweeping elbows or a tube bender will not be specified in the measure language since long radius elbows are sufficient to describe both hard wrought copper elbows and soft copper bent elbows. Moreover, tubing benders may also be used to produce short radius elbows, so not all tube bent elbows will be acceptable.

New Measure: *Short radius elbows are prohibited from use on commercial refrigeration systems unless space limitations physically prohibit the use of long radius elbows. Only under these circumstances can short radius elbows be installed. [Note: definitions of "short" and "long" radius elbows are based on catalogued terminology]*

Comment: Regarding the hydraulic or hammering effect, we also find heat reclaim coils get leaks at the 180-degree ends, usually due to liquid hammering. This is often because the system did not adequately pump out when turned off. I recommend a smaller bypass line (i.e., 5/8-7/8") be energized to slowly pressurize the coil before shifting the larger three-way valve. This will eliminate potential hammering and reduce leaks. (Robert Edison, Aztec-Energy)

> **Response:** It is acknowledged that hamming is an issue when a 3-way valve actuates; however, using smaller bypass lines is only a viable solution for three-way valves with pilot lines, not for valves without control lines. Another solution to reduce hammering would be to replace the solenoid valve with a motorized valve; however, motorized valves are not available for all solenoid applications at this time. Motorized valves would also increase the cost of installation and may create other problems. Since the hammering problem is only an issue in a small number of installations and there is not a universal solution to this problem, no additional measure is recommended at this time.

Comment: I recommend air conditioning motor rooms when located within 20 miles from the coast. Motor rooms close to the coast pull in humid salt air when the exhaust fan is turned on to cool down the motor room. This causes various rusting issues including steel lines, ball valve stems, EPR valves, etc. By air conditioning the motor room, the temperature is under control and so is the humidity. Other benefits are reduction of dirt and dust so technicians can more easily locate oil leaks. But it should be noted that some engineers will want to size motor room ACs using motor load BTU loads; this is NOT normally the correct sizing criteria, since refrigeration compressor windings are subcooled by the returning suction gas and then moved out through the discharge gas at several thousand CFM. This would apply if using open drive or direct drive motors. (Robert Edison, Aztec-Energy)

Response: Air conditioning is one solution for maintaining a motor room located near the coast; however, ventilation and other maintenance practices may also sufficiently address this problem. Additionally, it is beyond the scope of these leak reduction measures to mandate the use of air conditioning in motor rooms during operation. Such a mandate could also lead to adverse environmental impacts (i.e., increased GHG emissions) that result from increased energy consumption**.**

Comment: I still see a lot leaks on air cooled condensers, usually due to extreme thermal expansion (running higher than required head pressures, especially during the winter when the TD is greater), which should be addressed by using floating pressure controls. (Robert Edison, Aztec-Energy)

Response: Leaks on air cooled condensers are more commonly caused by the copper work hardening from the stress of continuous thermal changes from fan cycling. Floating head pressure is being proposed as an energy efficiency measure and is not expected to significantly impact refrigerant leaks. Alternatively, floating head pressure can lead to increased refrigerant charges which in turn can result in greater amounts of leaked refrigerant.

Comment: I didn't see anything regarding leak detection systems; why? (Robert Edison, Aztec-Energy)

Response: Leak detection and monitoring is covered by ARB's Refrigerant Management Program (Subarticle 5.1, sections 95380 to 95398 in Division 3, Chapter 1, Subchapter 10, Article 4, title 17, California Code of Regulations), available online at http://www.arb.ca.gov/cc/reftrack/reftrackrule.html#95385.

Comment: According to Jim Vannan—formerly with Super Valu and Wegman's, now with Winn-Dixie in Florida—Super Valu redesigned some stores from refrigeration heat reclaim (waste heat recovery) to hydronic heating. In doing so, they left the existing refrigeration heat reclaim coils in place but re-piped hot water to the coils, then used the waste heat from the refrigeration process to heat the water, which was located closer to the refrigeration system. This reduced the amount of refrigeration pipe, refrigerant charge, and potential leaks. Jim and I are concerned that some engineering firms will no longer take advantage of heat reclaim if their only focus is reducing refrigerant charges (not thinking of hydronic heating). I have had this voiced once already by a leading engineer in the supermarket industry. There are many benefits to this cogeneration process that we would hate to lose based on misinterpretations of the new proposed measures. Other ways heat reclaim can be used with limited pipe runs and/or additional refrigerant charges include the use of heat water for absorption air conditioning or refrigerant subcooling for subsequent use in back loading or stock rooms using a standard fan coil unit as a unit heater (when motor rooms are in or near back room) (Robert Edison, Aztec-Energy)

Response: Heat reclaim is being proposed as an energy conservation measure. There are no proposed leak reduction measures that would limit the use of heat reclaim.